

The Middle Eastern Biodiversity Network: Generating and sharing knowledge for ecosystem management and conservation

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Abstract

Despite prevailing arid conditions, the diversity of terrestrial and freshwater biota in the Middle East is amazingly high and marine biodiversity is among the highest on Earth. Throughout the Region, threats to the environment are moderate to severe. Despite the outstanding economic and ecological importance of biological diversity, the capacity in biodiversity-related research and academic education is inadequate. The “Middle Eastern Biodiversity Network” (MEBN), founded in 2006 by six universities and research institutes in Iran, Jordan, Germany, Lebanon and Yemen was designed to fill this gap. An integrated approach is taken to upgrade biodiversity research and education in order to improve regional ecosystem conservation and management capacities. A wide range of activities are carried out in the framework of the Network, including capacity building in biological collection management and professional natural history curatorship, developing university curricula in biodiversity, conducting scientific research, organising workshops and conferences on Middle Eastern biodiversity, and translating the results of biodiversity research into conservation and sustainable development.

Keywords

Middle Eastern biodiversity, nature museums, biodiversity research, biodiversity education, biodiversity conservation, biodiversity networks

Introduction

In the Middle East, like in many other parts of the world, a growing human population and increased demands for renewable resources are placing enormous stress on ecosystems and their floral and faunal inhabitants. As consumption of natural resources increases, so does the loss of biota, resulting in a decline of ecosystem services. This downward trend needs urgent attention, but for meaningful conservation measures, we need to know where plant and animal species occur, at what frequency and abundance, and understand the underlying patterns and processes.

Biodiversity has been defined by the United Nations Convention on Biological Diversity (CBD) as “The variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems, and the ecological complexes they are part of; this includes diversity within species, between species, and of ecosystems, embraces the total variability of all living organisms and the ecological complexes they inhabit” (United Nations 1993). The three levels of biodiversity – species, genetic and ecosystem diversity – are interacting with and influencing each other, and a change at one level causes changes at the other levels (Streit 2007). While many studies address species diversity, levels of genetic diversity are generally inadequately researched in the Region, despite the fact that they are major determinants of effective population size.

Throughout the Middle East, there is a multitude of threats to ecosystems and biodiversity. Habitat destruction is the most serious single cause of terrestrial biodiversity loss. Deforestation, hunting, overgrazing and degradation of rangelands have continued for millennia in this region of ancient civilisations. In recent decades, threats from urban and industrial developments and pollution have increased at an alarming speed. Some Middle Eastern countries have human population growth rates, which are among the highest in the world. Private ownership of agricultural land is still on the increase and there is a high level of competition for the limited freshwater resources. Water abstraction poses a very serious threat to the Region’s fragile aquatic biodiversity, and so do damming, the construction of channels and other alterations of watercourses. Coastal and marine environments are affected by increasing pressure from dredging and filling operations, disposal of domestic and industrial effluent, and disproportionate use of the limited freshwater resources. Tourism industries are experiencing rapid expansion, contributing to the overexploitation of living marine resources. The Region’s global importance for petroleum production and export and the resulting maritime traffic pose another serious threat to the marine environment. Both in continental and marine areas, the introduction of alien, invasive species, which compete with and sometimes replace indigenous species, may disrupt ecosystem functioning (Gladstone et al. 1999, Krupp et al. 2006).

Biodiversity, which is part of our life-support system, is of particular ecological, economic, spiritual, cultural, and aesthetic importance. The countries in the Middle East have ratified the CBD, with obligations to document and conserve the floras and faunas on their territories. In recent years, numerous projects focusing on sustainable

use and conservation of biological diversity have been initiated. However, the scientific and academic baselines are often lacking. The “Middle Eastern Biodiversity Network” (MEBN), founded in 2006 by six universities and research institutes in Arab countries, Iran and Germany was designed to fill this gap.

The strategic approach taken by the MEBN is presented here below, discussing challenges and opportunities to upgrade biodiversity research and education in a regionally integrated manner, improving capacities in environmental management and conservation throughout the Middle East.

The Middle East at a biogeographical crossroads

The position of the Middle East at the junction of Europe, Asia and Africa, the prevailing semi- to hyper-arid conditions, and a complex palaeogeographic history explain today’s composition, patterns and processes of continental and marine biodiversity. On a global scale, the Middle East is the only transition zone between three major biogeographic units, the Palaearctic, Afrotropical and Oriental Realms, resulting in an outstanding biogeographic significance and unique biological diversity.

A brief look at the palaeogeographic history of the Middle East, summarized in Wolfart (1987) and Brook et al. (2006), will allow us to better understand the Region’s present-day floral and faunal composition. From the Precambrian to the Palaeogene, the Afro-Arabian continental block formed a continuous plate. Up to the Lower Miocene, the Tethys Sea separated Africa and Arabia from Europe and Asia. Following the collision of the Arabian Plate with Eurasia during the Middle Miocene (ca 14 MA BP) and the formation of the Middle Eastern Landbridge, the Region was colonised by faunal elements of Palaearctic, Afrotropical and Oriental origin, and many new species evolved in the transition area. Semi-arid to arid conditions prevail since the formation of the Afro-Arabian desert belt during the Upper Miocene and the Landbridge became a floral and faunal filter, allowing some species to migrate among the three biogeographic realms, while forming an effective barrier for others.

The Tertiary faulting between Africa and Arabia resulted in the formation of the Red Sea rift. During the Eocene and Oligocene, a branch of the Tethys extended into the northern Red Sea depression, while the southern Red Sea rift valley contained freshwater lakes. During the Pliocene the Indian Ocean broke through the Strait of Bab al-Mandab, giving rise to the present Red Sea.

The Persian Gulf is of Pliocene to Pleistocene age and was formed by the same tectonic events that resulted in the formation of the Zagros Mountains. During the Pleistocene Glacials, when the sea level of the world’s oceans dropped by at least 120 m, the Gulf basin dried up and a river valley conducted the waters of Mesopotamia to the Gulf of Oman. Only some 17,000 years ago, the sea began rising again, reaching its present level about 5000 years ago. These events had major effects on today’s composition and distribution of freshwater and marine biota in the Region (Abuzinada and Krupp 1994).

The significance of Middle Eastern biodiversity

As a result of these formative events, the Middle East has a complex pattern of continental biodiversity with species originating from three major biogeographical realms. Increasing desiccation led to a fragmentation of habitats. Species with a formerly wide range of distribution were restricted to small areas of suitable habitat, resulting in high numbers of relict populations, many of which evolved as endemic taxa. Despite prevailing aridity, levels of biodiversity are amazingly high, higher than in most temperate areas of the same size. The Region's contribution to global biodiversity must be considered very high. Key terrestrial ecosystems are mountains, gravel plains, lava deserts (harras), sand sheets, sabkhas, urban biotopes, and modern and ancient agro-ecosystems (see below), each of them having its own unique vegetation and wildlife, which are usually strongly influenced by seasonality (Fig. 1). The Tigris-Euphrates, which drains through the Shatt al-Arab into the Persian Gulf, is the Region's largest river system. Other freshwater ecosystems include rivers, wadis (riverbeds with seasonal, intermittent stream flow), natural and artificial wetlands. Typical features of the Region are endorheic drainage basins, which are closed systems that do not drain to the ocean through rivers or underground diffusion. Each major physiographic unit supports some permanent wetlands as well as many ephemeral ones (Krupp and Schneider 1988).

The Levant and parts of Iran are considered globally important centres of agrobiodiversity with a great variety in wild relatives of important food crops and pasture species, which are an important source of genetic material for enhancing food crops. They are essential to satisfy basic human needs for food security. However, gene pools



Figure 1. Terrestrial biodiversity in the Middle East is strongly influenced by seasonality: Desert area in northern Saudi Arabia after the winter rainfall (photo F. Krupp).

of these crops, beneficial insects and microorganisms are diminishing rapidly, and so does the traditional knowledge on these plant species (Kontoleon et al. 2008).

The Arabian Seas Region is a distinct biogeographic unit in the north-western part of the Indian Ocean with some of the world's most unique coastal and marine environments, consisting of a wide range of ecosystems: An arid coastal zone, coastal wetlands, mangroves and salt marshes, seagrass beds, macroalgal beds and very extensive coral reefs. These ecosystems are the basis of the Region's extraordinarily rich marine biodiversity, which is vital to the livelihood of coastal populations. The Red Sea is the enclosed sea with the globally highest level of biodiversity (Gladstone et al. 1999; Fig. 2).

Upgrading biodiversity research and education: A strategic approach for planning and implementing conservation

The MEBN was founded in 2006 by six partner institutions: (1) The Senckenberg Research Institute, (2) the Goethe University, both Frankfurt am Main, Germany; (3) the American University of Beirut, Lebanon; (4) the Marine Science Station, Aqaba, Jordan; (5) the University of Sana'a, Yemen; and (6) the University of Tehran, Iran. The authors of this article are the coordinators of the Network, which from 2006 to 2008 was funded by the German Academic Exchange Service (DAAD).

The overall goal of the MEBN is to strengthen, within a multi-faceted network, the capacity of countries throughout the Middle East in documenting and analysing the Region's biodiversity, promoting sustainable resource use, and conservation. Given the transboundary nature of biodiversity issues, a regional approach was required and



Figure 2. Red Sea coral reef: The Red Sea is the enclosed sea with the highest biodiversity on Earth (photo F. Krupp).

networking was identified as the most appropriate solution. The objectives of the network are:

- To document biodiversity by building the regional capacity in establishing nature museums, charged with sampling, preserving and permanently storing biological collections as part of the national natural heritage, compiling biodiversity inventories, and making them available for scientific research and education;
- To train scientists and technicians throughout the Middle East in field collection methods, collection management and natural history curatorship;
- To analyse and understand the complex processes determining the Region's biodiversity, by conducting advanced research, developing and delivering academic courses on biodiversity and supervising graduate students;
- To strengthen regional networking through a biodiversity database, providing general access to information on collections;
- To translate biodiversity research into conservation and sustainable development.

To achieve these objectives, a wide range of research and educational programmes are implemented in the framework of the MEBN. As examples we are summarising, here below, three major areas of activities: (1) Capacity building in biological collection management and the establishment of nature museums, (2) upgrading biodiversity education, and (3) promoting dialogue.

The role of biological collections and nature museums

Collections of plant and animal specimens provide evidence of biological diversity with documented geographical data. They are important vouchers of the Region's biodiversity. Taxonomic research institutes and nature museums are essential to biodiversity research, education and conservation, providing suitable venues and materials to train scientists and environmental managers in biodiversity conservation. They allow verification of data collected and assure the greatest possible accuracy in environmental survey, assessment and monitoring activities (Stansfield et al. 1994). Nature museums also fulfil an important role in public education, supporting interactions of all age groups in different fields of science, and representing an asset to national tourism industries. They stimulate interest in the natural world, promoting awareness and enjoyment of the beauty of nature.

Consequently, the MEBN identified a clear need to compile biodiversity inventories and to establish museums with well-curated scientific reference collections of biological specimens as a basic requirement for the conservation and management of renewable resources at sustainable levels. In many parts of the world, academic training in biodiversity-related fields shifted from universities to museums during the last decades, but in the Middle East it is still the domain of universities, and most biological collections are associated with institutions of higher education. However, the Region has hardly any tradition and inadequate capacity in biological collection manage-

ment and natural history curatorship. While several important herbaria exist, there are only small, scattered zoological collections, which are in most cases neither adequately stored and catalogued, nor professionally curated. Most large and important plant and animal collections from the Middle East, some of them dating back to the 18th century, are permanently housed in European and North American museums.

The International Council of Museums (ICOM) defined a nature museum as “A non-profitmaking, permanent institution in the service of society and of its development, and open to the public, which acquires, conserves, researches, communicates and exhibits, for the purpose of study, education and enjoyment, material evidence of people and their environments” (ICOM 1990). At present not a single institution in the Middle East fulfils these requirements, even though several nature museums are now in the planning. Supporting these new initiatives, the MEBN is actively involved in building or upgrading the capacity of regional institutions charged with the documentation of biodiversity, providing advice and training.

To this end, the Network developed a training course on biological collection management and nature museum curatorship. The scope of this course was to build basic knowledge and skills in the establishment, maintenance, management and utilisation of biological collections, according to state-of-the-art international standards, with special regards to requirements in the Middle East. The course was delivered for the first time in 2006 at the Senckenberg Research Institute and Museum of Nature in Frankfurt am Main and in Wilhelmshaven, Germany (Fig. 3). Topics included: Functions and organisation of natural history collections; acquisition of specimens; preservation, documentation and maintenance of collections including specialised databases; use of collections, policies for access and loans of specimens; museum exhibition concepts; graphics and illustrations for exhibits; taxidermy and screen printing; the role of marketing in natural history museums; and museum education. Given the fact that most participants were rather senior and experienced, the course took the character of a “train-the-trainer” workshop, with a strong emphasis on discussion. Participants were given an opportunity to see the complex structure and functioning of a large, international taxonomic research institute and nature museum and its various departments. They gained a deeper insight into collection management and the benefits of natural history collections as archives of biodiversity for generations of researchers to come. The course was evaluated by the participants with regards to relevance and quality of each module, generating ideas for customising and delivering it in various parts of the Middle East. Specialised formal and on-the-job training for museum managers, scientists and technicians was subsequently delivered, both in the Region and in Germany.

Upgrading biodiversity education and research

Following the documenting of regional floral and faunal diversity, the next step was gaining a deeper understanding of the complex patterns and processes determining biodiversity in the Middle East. Addressing the need for further formal academic bio-

diversity education, the partners of the MEBN developed a two-week biodiversity course, titled “Biodiversity Fundamentals”, with each participating institution nominating senior scientists to work on developing the modules. The course strived to lay out fundamental theoretical aspects of biodiversity, using examples from the Middle East to explain concepts. It was designed as a first step for participating students to develop the technical and analytical skills needed for a career in biodiversity research, education, conservation, and management.

Before drafting the course modules, course developers agreed on objectives, conducted task analyses, and drafted module outlines, following a format similar to the highly successful United Nations “Train-X” methodology. Since course developers were based in Iran, Germany, Jordan, Lebanon and Yemen, an interactive e-mailing list was used for coordination, a crucial factor in ensuring continuity and consistency among the different course modules.

In June 2007, the course was delivered for the first time in Jordan. The first part was held at the University of Jordan in Amman, focusing on continental (terrestrial and inland water) biodiversity, while the second part at the Marine Science Station in Aqaba, focused on the marine environment. Modules were designed to provide theoretical foundations of biodiversity and then introduce a case study for each module, which would allow students to apply what they had learned. Students worked in groups to answer questions raised in the case studies, thereby also increasing the level



Figure 3. Collection management and museum curatorship training workshop: Participants sampling biological specimens aboard the RV “Senckenberg” (photo N. Manasfi).

of communication and mutual help among participants from different countries. In addition to coursework, the stay in Jordan included several opportunities for field studies, such as collating biodiversity and phyto-sociological field data in Ajloun (northern Jordan), or sampling near-shore habitats of the Red Sea. Following delivery, the course was evaluated, validated and customised for incorporation of appropriate elements into the curricula of the participating universities. It will also be made available to other universities in the Region via the MEBN communication network.

Students passing the course were offered further opportunities of specialised follow-up training tailored to their specific interests and needs. They also participated in a wide range of joint field research activities in Iran, Jordan, Lebanon or Yemen (Fig. 4). Several students conducted their B.Sc., Diploma, M.Sc. or Ph.D. projects in the framework of the MEBN at one of the participating universities or research institutes.

The role of dialogue in the conservation of biodiversity

Appreciation for the natural environment has deep roots both in the Middle East and in Europe, stimulating common biodiversity conservation values and stewardship ethics. Consequently one of the key concepts of the Network is finding solutions to



Figure 4. Joint field research in Yemen: Project participants sample fish in Socotra Island for studies of connectivity among populations. The results are important for fisheries management (photo U. Zajonz).

potential conflicts by dialogue, both between countries in the Middle East and Europe and within the Middle East. Conflicts in the Region have major impacts on biodiversity, but cooperation across national boundaries is inadequate. Given the ecological and economic importance of biodiversity research, education and conservation – above all in the light of climate change – biodiversity researchers must find ways to overcome present barriers to fulfilling their societal duties, building on the great potential that science offers for bridging gaps. The very survival of the Region's flora and fauna is at stake, and we are still far away from viable solutions to these pressing problems. Addressing this issue, a series of workshops and conferences have been organised, three of which are being briefly reviewed here below.

In December 2006 an international, interdisciplinary workshop titled: “The biodiversity conservation imperative: Biological, ethical, and economic approaches in the Middle East and Europe” was held at the University of Tehran, Iran. The goal of this workshop was to outline and discuss the biological, ethical and economic principles of preserving the diversity of life, promoting mutual understanding and identifying common values in conservation approaches prevalent in the Middle East and Europe. It became obvious that the dramatic nature of the biodiversity crisis necessitates urgent action and the biodiversity conservation imperative is a race against time. Our common responsibility for preserving the diversity of life requires interdisciplinary approaches and dialogue. The workshop responded directly to these requirements. Scholars and students of biology, philosophy, law, history, economics and environmental management from both Europe and the Middle East participated. The first part, arriving at a common understanding of the definitions of biodiversity, set the scene for the subsequent discussions. Philosophical, ethical and religious approaches to conservation were presented and discussed next. In the West, for example, very little is known about the basic perspectives and ethical principles of Islamic theology on the environment. The transmission of this knowledge proved essential for a mutual understanding of conservation values. Subsequently, the economic imperatives of biodiversity conservation in the Middle East were discussed. Finally, western philosophical foundations and conservation ethics were presented, followed by round-table discussions in which the common grounds and future opportunities for collaboration were highlighted.

Owing to its rich biodiversity and a very high degree of endemism, the Socotra Archipelago, Yemen, is often termed the “Galapagos of the Indian Ocean”. In October 2007, a specialised and highly focused workshop “Synoptic Biogeography of Socotra Archipelago” was held at the University of Sana'a, Yemen, bringing together biogeographers to discuss research methods, compare results, and come up with a synoptic view of the biogeography of this very unique archipelago. The results of this workshop served as a case study for biogeographic research in the Region and a model for an integrated approach to tackling complex scientific problems. It helped in transferring knowledge and upgrading the scientific capacity in biogeography research in the Region.

The largest conference organised thus far by the MEBN was the “First Middle Eastern Biodiversity Congress” held in Aqaba, Jordan, in October 2008. More than 500 scientists and students registered and more than 300 attended the sessions, special-

ised symposia and workshops. Emerging issues received special attention, particularly climate change and its impact on biodiversity, which was the theme of one of the symposia. Although reliable scenarios of possible pathways of future climate change are available, relatively little is known about the consequences. Global warming is likely to affect all conservation related fields and there is an urgent need to get prepared for the future challenges. Pressing issues related to climate change and research needs in the Region were discussed.

Throughout the Middle East, competition for the limited freshwater resources is a potential source of armed conflicts. A symposium titled “Towards a Regional Biodiversity Initiative for the Tigris-Euphrates Basin” presented and discussed projects assessing the status and character of biologically rich areas in the Region’s largest river basin, such as wetlands, riparian zones, lakes and sea shores. For the first time, scientists of all riparian countries (Iran, Iraq, Kuwait, Syria, and Turkey) set together, discussing the development of a multi-partner Basin-wide Tigris-Euphrates Headwaters to Ocean (“H2O”) programme. “Nature Iraq” and the “Twin Rivers Institute” of Iraq in conjunction with BirdLife International organized this symposium and it was agreed that regular meetings addressing these important issues will be organised in the future.

Other sessions, symposia and workshops addressed marine biodiversity, continental botany and zoology, herbarium resources in the Levant, biodiversity conservation and management, important bird areas and innovative approaches for bird conservation, natural history collections and museum management, and training of professionals in museum education on biodiversity. In many regards, the Aqaba Congress started shaping the future of the MEBN.

The MEBN focuses on building regional capacity in biodiversity research and education. A key objective is making the results available to peers, decision makers and the general public, above all with regards to their use for applied fields, such as conservation, coastal zone management, fisheries management, agriculture and forestry. Dissemination of results produced by scientists participating in the Network is usually done through formal publication in scientific journals. Additionally, articles were written for popular magazines to promote awareness and stimulate public discussion.

The future of the Middle Eastern Biodiversity Network

In December 2008, the coordinators of the MEBN met at the Biology Department, American University of Beirut, Lebanon, to review activities of the first three years and discuss the future of the Network. The MEBN will continue as a regional, not-for-profit Association and a draft Constitution and Bylaws were agreed upon. It was decided to transfer the coordination of the MEBN from Frankfurt to the Middle East and to open up membership to other regional and international universities, research institutes, national and regional environmental organisations and NGOs. Based on the success of the First Middle Eastern Biodiversity Congress and the strong interest of biodiversity researchers in holding such conferences on a regular basis in the future, it

was envisaged holding the Congress every three years. One regional institution will be taking up the coordination of the MEBN for a period of three years. It will organise the Congress and then hand over the coordination of the Network to another institution in another country. Networking will be strengthened further through a regional biodiversity database, providing general access to information on biological collections, sharing and exchanging ideas, concerns and interests with all organisations involved in the communication process.

Outreach activities for a wide range of target groups will increase awareness about biodiversity issues. Museums of nature, zoos, and aquaria play an important role in informing and educating the general public. The MEBN will cooperate with the press in disseminating information. Broad-based public consultation and participation are expected to improve the quality, effectiveness and sustainability of awareness programmes. The MEBN will also link up with other biodiversity networks world-wide (e.g. Kruttschinn and Streit 2009).

During its first years, the MEBN has achieved many of its objectives, but the challenges ahead of us are still tremendous. We encourage all partners to continue the dialogue initiated through the Network, and we aspire to an environment where biodiversity conservation and responsible management of renewable resources will safeguard the Region's unique diversity of life and allow people to control their food and livelihood supply systems, where the benefits from biological resources are fairly shared, and where citizens are able and encouraged to help making informed policy choices.

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References

- Abuzinada AH, Krupp F (1994) The Arabian Gulf environment and the consequences of the 1991 oil spill. *Courier Forschungsinstitut Senckenberg* 166: 3–10.
- Brook MC, Al Shoukri S, Amer KM, Böer B, Krupp F (2006) Physical and environmental setting of the Arabian Peninsula and surrounding seas. *Policy Perspectives for Ecosystem and Water Management in the Arabia Peninsula*. UNESCO Doha and United Nations University, Hamilton, Ontario, pp. 1–16.
- Gladstone W, Tawfiq N, Nasr D, Andersen I, Cheung C, Drammeh H, Krupp F, Lintner S (1999) Sustainable use of renewable resources and conservation in the Red Sea and Gulf of Aden: issues, needs and strategic actions. *Ocean and Coastal Management* 42: 671–697.
- ICOM (1990) ICOM statutes and code of professional ethics. International Council of Museums, Paris, 35 pp.
- Kontoleon A, Pascual U, Smale M (Eds) (2008) *Agrobiodiversity Conservation and Economic Development*. Routledge, Independence, Kentucky, 456 pp.
- Krupp F, Al-Muftah A, Jones DA, Hoolihan J (2006) Marine and coastal ecosystem management requirements in the Arabian Peninsula with special regard to water resources. *Policy Perspectives for Ecosystem and Water Management in the Arabian Peninsula*. UNESCO Doha and United Nations University, Hamilton, Ontario, pp. 73–87.
- Krupp F, Schneider W (1988) Die Süßwasserfauna des Vorderen Orients - Anpassungsstrategien und Besiedlungsgeschichte einer zoogeographischen Übergangszone. *Natur und Museum* 118(7): 193–213.
- Krutschinna J, Streit B (2009) The biodiversity network BioFrankfurt: An innovative strategic approach to integrative research, conservation, and education. In: Krupp F, Musselman JL, Kotb MMA, Weidig I (Eds) *Environment, Biodiversity and Conservation in the Middle East*. Proceedings of the First Middle Eastern Biodiversity Congress, Aqaba, Jordan, 20–23 October 2008. *BioRisk* 3: 21–26.
- Stansfield G, Mathias J, Reid G (Eds) (1994) *Manual of Natural History Curatorship*. HSMO, London, xviii + 306 pp.
- Streit B (2007) *Was ist Biodiversität? Erforschung, Schutz und Wert biologischer Vielfalt*. C.H. Beck Publishers, Munich, 125 pp.
- United Nations (1993) *Convention on Biological Diversity*. United Nations Treaty Series, vol. 1760, Article 2.
- Wolfart R (1987) Late Cretaceous through Quaternary palaeogeographic evolution of the Middle East. In: Krupp F, Schneider W, Kinzelbach R (Eds) *Proceedings of the Symposium on the Fauna and Zoogeography of the Middle East*, Mainz 1985. Beihefte zum Tübinger Atlas des Vorderen Orients, Ludwig Reichert, Wiesbaden, A 28: 9–22.